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Dietary Enzyme Supplementation as a Method of Improving the Nutritional Value of Cereal Grains

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DIETARY ENZYME SUPPLEMENTATION AS A METHOD OF IMPROVING THE NUTRITIONAL VALUE OF CEREAL GRAINS

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The objectives of this project were to study the practical use of dietary enzymes for improving the nutritional value of Saskatchewan grown cereal grains. Cereal grains such as barley and oats are not considered good feed ingredients for poultry. With both barley and oats, the relatively high level of crude fibre is not digested by the chicken. But more important are carbohydrate constituents which are very viscous in water and cause a reduction in the digestion and absorption of nutrients by the bird. Research in our lab has demonstrated that dietary enzymes can break down the deleterious carbohydrate and make barley and oats more nutritious for poultry. This study was designed to examine the use of dietary enzymes in diets for broiler chickens, laying hens and turkeys.

A broiler chicken trial was completed to confirm the beneficial effects of enzyme addition using barley samples from different genetic backgrounds and grown in a wide range of Saskatchewan grown locations. Regardless of genetic or geographical background, barley samples supported good growth rate with only minor differences among samples. Considerable variation in efficiency of feed utilization was noted and appeared at least in part to be related to the crude fibre content of the sample. Growth rate of chickens fed barley was not as good as birds fed wheat-corn diets, although the differences were relatively small. The results suggest that a dietary enzyme source makes barley samples more uniform, an asset when formulating diets. An experiment with laying hens examined the impact of 4 levels of dietary enzyme (0.0, 0.0125, 0.0250 and 0.0500%) on the nutritional value of wheat hulled barley and hull-less barley. Enzyme addition caused a significant increase in egg production and decrease in mortality with the beneficial effects being similar for the 0.025 and 0.050% levels. The response occurred in all three cereal grain types. No major effect of enzyme addition was noted for egg quality, feed conversion or hen body weight. A battery brooder study with turkeys confirmed the beneficial effect of dietary enzymes on the feeding value of hulled and hull-less barley and the lack of effect in wheat diets. Both liveweights and feed efficiencies were improved by the enzyme source. Similar results were obtained from a floor study with turkey broilers. Enzyme addition improved growth rate of turkeys fed hulled and hull-less barley from 0 to 4 and 0 to 8 wks of age, respectively; feed efficiency was improved for both barley types from 0 to 8 wks of age. No significant benefits were noted for wheat diets throughout the trial or for any of the cereal grains from 8 to 12 wks of age. There was no evident distinction between birds fed the barley diets from day 1 or 4 wks of age and therefore there is no evidence for adaptation of birds to barley diets. In another turkey broiler trail, birds fed hull-less barley plus enzyme were found to tolerate lower levels of vitamin D_3 and available phosphorus than those fed hull-less diets without the enzyme.

The major benefit of our results is the use of cheaper, locally grown feed grains in poultry rations. This would improve the competitive advantage of Saskatchewan poultry producers by taking advantage of nearness to a major feed grain production area. Information on the utilization of barley and enzymes in poultry diets may also improve the export value of barley because sales for poultry feed represent an important component of the feed grain market.

DIETARY ENZYME SUPPLEMENTATION AS A METHOD OF IMPROVING THE NUTRITIONAL VALUE OF CEREAL GRAINS

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ABSTRACT

Studies were undertaken to examine and clarify the effect of dietary enzyme sources containing β-glucanase activity on the feeding value of barley for broiler chickens, laying hens and turkeys. A broiler chicken trial was completed to confirm the beneficial effects of enzyme addition using barley samples from different genetic backgrounds and grown in a wide range of Saskatchewan grown locations. Regardless of genetic or geographical background, barley samples supported good growth rate with only minor differences among samples. Considerable variation in efficiency of feed utilization was noted and appeared at least in part to be related to the crude fibre content of the sample. Growth rate of chickens fed barley was not as good as birds fed wheat-corn diets, although the differences were relatively small. The results suggest that a dietary β-glucanase containing enzyme source makes barley samples more uniform, an asset when formulating diets. An experiment with laying hens examined the impact of 4 levels of dietary enzyme (0.0, 0.0125, 0.0250 and 0.0500%) on the nutritional value of wheat (W), hulled barley (B) and hull-less barley (HB). Enzyme addition caused a significant increase in egg production and decrease in mortality with the beneficial effects being similar for the 0.025 and 0.050% levels. The response occurred in all three cereal grain types suggesting that the effect might be due to something other than β-glucanase activity. No major effect of enzyme addition was noted for egg quality, feed conversion or hen body weight. A battery brooder study with turkeys confirmed the beneficial effect of dietary enzymes on the feeding value of B and HB and the lack of effect in wheat diets. Both liveweights and feed efficiencies were improved by the enzyme source. Similar results were obtained from a floor study with turkey broilers. Enzyme addition improved growth rate of turkeys fed B and HB from 0 to 4 and 0 to 8 wks of age, respectively; feed efficiency was improved for both barley types from 0 to 8 wks of age. No significant benefits were noted for wheat diets throughout the trial or for any of the cereal grains from 8 to 12 wks of age. There was no evident distinction between birds fed the barley diets from day 1 or 4 wks of age and therefore there is no evidence for adaptation of birds to barley diets. In another turkey broiler trial, birds fed HB plus enzyme were found to tolerate lower levels of vitamin D_3 and available phosphorus than those fed HB diets without the enzyme.

BACKGROUND AND OBJECTIVES

In the past several years a major emphasis of this laboratory has been

the study of the influence of viscous carbohydrate gums present in rye, barley and oats on the productivity of poultry. Convincing evidence indicates that pentosans in rye and β-glucans in barley and oats increase the viscosity of the intestinal digesta of birds and either directly or indirectly decrease nutrient retention. As a consequence, growth rate and efficiency of feed utilization are reduced. In barley, the level of β-glucan has been shown to change as a result of growing and harvesting environmental conditions, with the normally dry conditions in Saskatchewan increasing the β-glucan content.

Previous results from this study indicated that enzyme sources containing β-glucanase activity could eliminate the negative effect of feeding barley to broiler chickens. A similar but less consistent effect was shown for turkeys. It is hypothesized that the enzyme reduces the viscosity of the β-glucan and thereby improves broiler performance. The major practical implication of these results is the potential for increased use of lower cost feed ingredients such as barley and oats in poultry rations, where they have been traditionally considered inferior.

The objectives of the present study were as follows: 1) to study the practical use of dietary enzymes for improving the nutritional value of barley; and 2) to study the use of dietary enzyme supplementation in broiler chicken, laying hen and turkey diets.

EXPERIMENTAL METHOD

To study the effects of dietary enzyme supplementation, 1 broiler chicken, 1 laying hen and 3 turkey experiments were completed.

Experiment 1. A total of 2,400 broiler chickens were housed in litter floor pens and raised to a market age of 42 days. To establish if enzyme addition would increase the uniformity of barley samples for feeding broilers, 11 different cultivars of barley were purchased from locations throughout the province and used to manufacture broiler starter and finisher diets. The barley cultivars and areas of production are as follows: Hector (Coronach); Bedford (Maryfield); Diamond (Wroxton); Harrington (Admiral); Johnston (Steward Valley); Klages (Unity); Leduc (Delmas); Norbert (Lemberg); Otal (Nipawin); Scout (Rosthern); and Tupper (Hague). Wheat-corn diets were used as a control to judge overall production. An enzyme source derived from Aspergillus niger fermentation was added at 0.025% of the diet. The presence of a high level of β-glucanase in this product has been shown in previous studies. All treatments were fed to 4 pens each housing 50 broilers.

Experiment 2. To study the effect of enzyme addition on the performance of laying hens, 960 birds were fed diets containing wheat, hulled barley or hull-less barley in combination with 0.0, 0.0125, 0.0250 or 0.0500% dietary enzyme derived from B. subtilis. Form of diet (pellet vs mash) was also examined by splitting every feed mix in two and pelleting one half and leaving the other half as mash. Hens were maintained on trial for 6 periods of 28 days each, starting when the birds were 20 wks of age. Parameters examined included egg production, egg weight, egg shell quality (specific gravity), feed per dozen eggs, body weight and incidence of mortality.

Experiment 3. Previous battery brooder studies failed to support the beneficial effect of dietary enzymes on the performance of turkeys fed diets containing barley or oats. However, these results were confounded by the use antibiotic treatment which is also known to improve the performance birds fed barley. Therefore this study was conducted to evaluate the effect of enzyme supplementation (B. subtilis, 0.025%) in the absence of antibiotic treatment. A total of 162 male Medium White poults were used to this battery brooder study, which lasted 6 wks.

Experiment 4. A second turkey experiment involved 800 Medium White turkeys and extended from day-old to a market age of 12 wks. Previous data from a floor pen study showed that β-glucanase improved performance of birds fed hulled or hull-less barley to 4 wks of age, but had little effect past that age. This experiment was designed to determine whether the apparent ineffectiveness of enzyme supplementation represents an improved ability of older turkeys to utilize barley or a form of adaptation to diets containing β-glucan. The effect of introducing barley or hull-less barley into the diet, with or without enzyme (B. subtilis, 0.025%), at 4 wks of age was compared with that of comparable diets fed from day 1.

Experiment 5. Diets containing HB (with or without a β-glucanase enzyme source, .02% B. subtilis) or each supplemented with different concentrations of vitamin D_3 (2500 or 900 IU/kg feed) and available phosphorus (commercially recommended or low regime) were fed to broiler-type turkeys to 12 weeks of age. The objective was to determine the effects of dietary treatments on performance, carcass quality and the incidence of leg problems.

RESULTS AND DISCUSSION

Experiment 1. Mean 6 wk body weight of broilers fed diets containing barley ranged from 1.702 to 1.779 kg (Table 1), which is comparable to commercial standards but lower than the mean body weight of broilers fed the wheat-corn diet (1.821 kg). Although this difference is significant, it only represents from less than 1 to a 2 day change in age required to reach a comparable body weight. It should be noted that the wheat-corn treatment was approximately 100 kcal/kg higher in metabolizable energy than the barley diets, a difference that could account for some of the reduction in growth rate. As expected, feed to gain ratios were higher for the barley treatments than the wheat-corn control; the range for barley fed birds was 1.946 to 2.107 while the mean for the wheat-corn treatment was 1.931 (Table 1). It would appear that at least a portion of variation in feed to gain ratio among barley samples can be attributed to crude fibre levels. Mortality levels were high, primarily due to an outbreak of necrotic enteritis. No obvious treatment effects on mortality were noted.

Experiment 2. Enzyme addition to laying hen diets resulted in a linear increase in egg production and a linear decrease in mortality with higher levels of supplementation. No effects of enzyme addition were noted for feed conversion, body weight gain, egg weight or egg specific gravity (Tables 2, 3, 4 and 5). The enzyme effect did not appear to be related to β-glucanase activity as the response in wheat diets, which contain low levels of β-glucan, was similar to that for the two barley samples.

Cereal grain had a significant effect on egg production, feed conversion and body weight gain. Feeding hulled barley resulted in numerically higher hen-day egg production than hens fed hull-less barley and significantly higher production than the wheat fed birds. The ranking for hen-housed egg production was changed because of the nearly significant high level of mortality observed for hens fed hull-less barley. The major cause of mortality during the trial was lymphoid leukosis which is not thought to be influenced by nutritional programs. The effect on hen-housed production of the hull-less barley treatment is therefore thought to be chance occurrence. The feed per dozen eggs values for the hull-less barley, wheat and hulled barley fed hens were 1.518, 1.602 and 1.655, respectively; all differences were statistically significant. Wheat and hull-less barley feeding resulted in similar weight gains (.407, .408 kg) during the experimental trial while hens fed hulled barley gained significantly less (.293 kg). The effects of cereal grain on egg quality parameters were small and inconsistent.

Diet form was studied because of the potential effects of the pelleting process on enzyme activity and the ability of hens to consume the bulkier hulled barley diets. Although differences in hen-day production were not significantly different for the entire trial, mash fed birds laid significantly more eggs during the fifth and sixth periods. This is likely related to the significantly larger weight gain for pellet fed hens. Note that the hens fed hulled barley were also the lightest and laid the most eggs. Pelleting resulted in a significantly higher feed conversion value and also a higher egg weight in 4 of the 6 periods.

Experiment 3. Enzyme supplementation had no effect on performance with wheat diets but improved liveweights and particularly feed efficiencies with diets based on hulled or hull-less barley (Table 6). Thus, the effectiveness of β-glucanase enzyme in improving the utilization of barley by growing turkeys is confirmed in battery trials.

Experiment 4. Inclusion of β-glucanase enzyme in starter diets (0 to 4 wks) improved both weight gain and feed efficiency with hulled and hull-less barley, but not wheat diets (Table 7). From 4 to 8 wks the enzyme had little effect on the rate of gain of birds fed regular barley, but improved gains with hull-less barley, while feed efficiency was improved by the enzyme with both barley types. There was no evident distinction between birds fed the barley from day 1 or 4 wks of age, therefore there is no evidence of adaptation to barley diets. The enzyme treatment had a little apparent effect from 8 to 12 wks of age, except a possible tendency to improved weight gains in the presence of the enzyme.

Experiment 5. The hull-less barley plus enzyme (HB+E) diets significantly increased liveweight over the hull-less or W diets by 4 weeks but not by 12 weeks of age. At 4 weeks birds fed the HB+E diets were as efficient in feed conversion as those fed W-based diets but by 12 weeks HB-based diets with or without the enzyme were inferior to the W diets. A significant cereal x available phosphorus x vitamin D_3 interaction at 4 weeks showed the pronounced effect of the lower dietary available phosphorus and vitamin D_3 concentrations on reducing body weight of birds fed HB-based diets without the β-glucanase enzyme. Mortality, incidence of leg problems and carcass quality were not affected by diet. Tibia ash was greater for birds fed diets containing HB+E, .7% available phosphorus or 2500 IU vitamin D_3/kg

feed compared with those fed W or HB without enzyme, .4% available phosphorus or 900 IU vitamin D_3/kg feed, respectively (Table 8).

Overall results showed that HB plus a β-glucanase enzyme source can replace W as a major cereal grain in diets for turkeys. Birds fed HB+E diets can tolerate lower levels of vitamin D_3 and available phosphorus supplementation than those fed HB diets without the enzyme.

IMPACT

In all trials conducted during this year enzyme supplementation of barley diets has resulted in high production levels. In young chickens and turkeys the advantage of enzyme addition is marked while in laying hens the advantage is less dramatic. The major benefit of these results is the potential reduction in feed costs as a result of the use of cheaper, locally grown feed grains in poultry rations. This would act to improve the competitive advantage of Saskatchewan poultry producers by taking advantage of nearness to a major feed grain production area. Information on the utilization of barley and enzymes in poultry diets may also improve the export market potential of both hulled and hull-less barley because sales for poultry feed represent an important component of the feed grain market.

RESEARCH PAPERS

Classen, H.L., G.L. Campbell, and J.W.D. GrootWassink, 1988. Improved feeding value of Saskatchewan-grown barley for broiler chickens with dietary enzyme supplementaiton. Can. J. Anim. Sci. (Submitted for publication).

Stevens, V.I., R.E. Salmon, H.L. Classen and G.L. Campbell, 1988. Effects of dietary β-glucanase, vitamin D_3 and available phosphorus on the utilization of hulless barley by broiler turkeys. Nutr. Rep. Int. (Submitted for publication).

Table 1. The effect of different barley samples fed in combination with enzymes on the performance of broiler chickens.

Barley sample	Average 6 wk wt (kg)	F/G ratio (0-6 wks)	Total mortality (%)
Hector (Coronach)	1.702	2.055	10.50
Bedford (Maryfield)	1.750	2.010	9.00
Diamond (Wroxton)	1.764	2.107	7.50
Harrington (Admiral)	1.704	2.012	9.00
Johnston (Steward Valley)	1.723	2.033	13.00
Klages (Unity)	1.717	2.081	8.00
Leduc (Delmas)	1.779	1.946	9.50
Norbert (Lemberg)	1.755	2.102	15.50
Otal (Nipawin)	1.710	2.070	15.50
Scout (Rosthern)	1.740	1.984	12.50
Tupper (Hague)	1.734	2.057	11.50
Wheat-corn control	1.821	1.931	10.00

Table 2. Effect of cereal grain, dietary enzyme level and diet form on various parameters of laying hens.

Treatments	Egg production (%)		Feed per dozen eggs
	Hen-day	Hen-housed	
Cereal grains			
Wheat	86.8[b]	83.8[b]	1.602[b]
Hulled barley	88.5[a]	86.4[a]	1.655[a]
Hull-less barley	87.3[ab]	82.1[c]	1.518[c]
	.0212	.0107	.0001
Enzyme Level (%)			
0.000	86.5	81.4	1.561
0.0125	87.2	83.8	1.599
0.0250	88.2	85.3	1.604
0.0500	88.2	85.9	1.602
Linear Regression	.0183	.0104	NS
Diet Form			
Pellet	87.1	83.8	1.641[a]
Mash	88.0	84.4	1.542[b]
	NS(.0621)	NS	.0001
Interactions	NS	NS	NS

Table 3. Effect of cereal grain, dietary enzyme level and diet form on the body weight gain and mortality of laying hens

Treatments	Body weight gain (g)	Mortality (%)
Cereal grain		
Wheat	.407[a]	6.25
Hulled barley	.293[b]	5.06
Hull-less barley	.408[a]	9.69
	.0001	NS (.0679)
Enzyme Level (%)		
0.000	.360	10.92
0.0125	.372	7.08
0.0250	.378	5.42
0.0500	.364	4.58
Linear regression	NS	.0094
Diet Form		
Pellet	.407	6.67
Mash	.330	7.33
	.0001	NS
Interactions	CG*Enz	NS

Table 4. Effect of cereal grain, dietary enzyme level and diet form on the egg weight of laying hens

	Egg weight (g)					
	Period					
Treatment	1	2	3	4	5	6
Cereal Grain						
Wheat	52.7	55.2	56.8	58.9	60.6	60.7
Hulled barley	52.6	55.9	57.7	59.3	61.3	61.2
Hull-less barley	53.2	56.3	58.4	60.1	60.9	61.5
	NS	.0313	.0070	NS	NS	NS
Enzyme Level (%)						
0.000	52.6	55.4	57.8	59.0	60.3	61.3
0.0125	53.3	56.0	57.8	59.1	60.9	60.9
0.0250	52.2	55.7	57.7	60.1	61.0	61.1
0.0500	53.3	56.2	57.3	59.6	61.6	61.3
	NS	NS	NS	NS	.0369	NS
Diet Form						
Pellet	53.2	56.3	58.2	59.9	61.5	61.4
Mash	52.5	55.3	57.1	59.0	60.4	60.9
	NS	.0064	.0117	.0231	.0095	NS
Interactions	NS	NS	NS	NS	NS	NS

Table 5. Effect of cereal grain, dietary enzyme level and diet form on the specific gravity of hen eggs

	Specific gravity					
	Period					
Treatment	1	2	3	4	5	6
Cereal Grain						
Wheat	1.082	1.083	1.082	1.080	1.082	1.077
Hulled barley	1.082	1.084	1.083	1.082	1.083	1.079
Hull-less barley	1.082	1.083	1.082	1.080	1.082	1.078
	NS	NS	NS	.0378	NS	NS
Enzyme Level (%)						
0.000	1.082	1.083	1.083	1.080	1.083	1.078
0.0125	1.082	1.083	1.082	1.081	1.083	1.076
0.0250	1.082	1.084	1.082	1.080	1.082	1.077
0.0500	1.083	1.084	1.083	1.082	1.083	1.079
	NS	NS	NS	NS	NS	NS
Diet Form						
Pellet	1.083	1.083	1.082	1.081	1.082	1.078
Mash	1.082	1.084	1.083	1.080	1.081	1.077
	.0061	NS	NS	NS	NS	NS
Interactions	Enz*diet (.0449)	NS	Enz*diet (.0091)	NS	NS	NS

Table 6. Effect of B-glucanase supplementation on liveweights and feed efficiency of male poults to 6 wks of age.

Cereal in diet	Enzyme added (%)	Liveweight (kg)			Gain/feed ratio		
		0.00	0.01	0.02	0.00	0.01	0.02
Wheat		1.86	1.82	1.91	.653	.654	.654
Barley		1.76	1.88	1.88	.593	.639	.634
Hull-less barley		1.79	1.82	1.83	.582	.621	.648

Table 7. Effect of B-glucanase supplementation on weight gain and feed efficiency of turkey broilers to 12 wks of age.

Cereal in diet	0-4 wks		4-8 wks		8-12 wks	
	Wt gain (kg)	Gain/ feed ratio	Wt gain (kg)	Gain/ feed ratio	Wt gain (kg)	Gain/ feed ratio
Wheat	.837	.707	2.09	.587	2.49	.424
Wheat + enzyme	.829	.701	2.12	.558	2.54	.418
Barley 0-12 wks	.751	.618	2.06	.535	2.51	.415
Barley +enzyme	.828	.697	2.09	.565	2.54	.417
Barley 4-12 wks	1		2.05	.530	2.43	.404
Barley + enzyme			2.09	.566	2.51	.413
Hull-less barley (HB) 0-12 wks	.637	.562	1.85	.504	2.41	.411
HB + enzyme	.847	.693	2.11	.558	2.55	.408
HB 4-12 wks	1		2.01	.524	2.32	.407
HB + enzyme			2.14	.567	2.56	.412

1 Wheat diets were fed from 0-4 wks.

Table 8. Effects of enzyme supplement, available phosphorus and Vitamin D_3 on tibia ash (% dry weight) of 2-week-old poults fed hull-less barley- or wheat-based diets

Phosphorus, available (%)	Vitamin D_3 (IU/kg feed)	Cereal			Mean
		Wheat	Hull-less barley	Hull-less barley + enzyme	
.7	2500	54.67	54.50	54.98	54.72
	900	52.23	52.99	54.23	53.15
.4	2500	51.20	51.83	52.22	51.75
	900	50.11	50.46	51.31	50.62
Means					
Vitamin D_3	2500	52.94	53.17	53.60	53.23[a]
	900	51.17	51.73	52.77	51.89[b]
Phosphorus, available	.7	53.45	53.75	54.61	53.93[a]
	.4	50.66	51.15	51.76	51.19[b]
Cereal		52.05[a]	52.45[a]	53.18[b]	

[a,b] Within each treatment mean values with different superscripts are significantly different ($P<.05$).

6-83-84

DIETARY ENZYME SUPPLEMENTATION AS A METHOD OF IMPROVING THE NUTRITIONAL VALUE OF CEREAL GRAINS

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ABSTRACT

Studies were conducted to examine the effects of a dietary enzyme source (Zymo-Best) on the feeding value of various cereal grains for broiler chickens and turkeys. In 2 trials the enzyme supplement markedly improved the growth and feed efficiency of broiler chickens fed hulled or hulless barley. Although maximum performance was obtained when 25,000 ppm of the enzyme source was added, a range of 125 to 250 ppm was adequate to produce the majority of the improvement in performance. The results with chickens also demonstrated that enzyme supplementation was beneficial throughout the broiler production cycle and in diets which were pelleted and contained anticoccidial agents and growth promotants. Results from 3 trials with turkeys were not consistent. In an initial battery trial, enzyme supplementation of turkey diets containing wheat, hulled barley, hulless barley or oat groats did not improve growth rate or feed efficiency regardless of level of enzyme addition (0, 100, 200, 300, 400, 800 or 1600 ppm). In a second trial, enzyme supplementation numerically improved the performance of turkeys fed hulless barley or oat groats while in a third trial performance was significantly improved from 0 to 4 wks of age for turkeys fed hulled or hulless barley. Production parameters for the remainder of the cycle in the latter trial (4 to 13 wks) were unaffected by enzyme supplementation but the final data for the entire experimental period still reflected the superior early performance. A gel diffusion assay for ß-glucanase activity was modified for use as a quality control procedure for enzyme supplements or diets.

BACKGROUND AND OBJECTIVES

In the past several years a considerable amount of research has focused on the influence of viscous carbohydrate gums present in rye, barley and oats on productivity of young chicks. Convincing evidence indicates that pentosans in rye and ß-glucans in barley and oats increase viscosity of the intestinal digesta and either directly or indirectly decrease nutrient retention. As a consequence growth rate and efficiency of feed utilization are reduced. In barley the level of ß-glucan has been shown to change as a result of growing and harvesting environmental conditions, with the normally dry conditions in Saskatchewan increasing ß-glucan content.

A number of treatments have been shown to reduce the effect of these viscous carbohydrates, including: water extraction; supplementation of diets with high levels of antibiotics; grain gamma irradiation; and use of dietary enzymes. The latter treatment has been tested in our laboratory and the results have indicated that several crude enzyme sources (Cellulase 4000, Spark-L HPG, Ultrazym 100 · pectinase, Zymo-Best) improved the feding value of grains containing viscous gums. It is hypothesized that the crude enzyme sources reduce the viscosity of the gums and thereby improve performance. The cost of enzyme supplementation in practical diets is cost prohibitive for all but

one source tested. Zymo-Best (PPM Fermentation Products Inc., Milwaukee, Wisconsin), which is derived from B. subtilis fermentation, appears from our chick trials to be cost effective and worthy of further study. The major practical implication of enzyme supplementation is the potential for increased use of lower cost feed ingredients such as barley and oats in poultry diets, where they have traditionally been considered inferior. Although a promising procedure, more data are required prior to recommendation of dietary enzymes in poultry rations.

The objectives of the present study were as follows: 1) to study the practical use of dietary enzymes in improving the nutritional value of cereal grains; 2) to study the effects of dietary enzyme supplementation in chicken broiler and turkey diets; and 3) to study factors affecting the stability of enzyme sources and establish techniques to be used in enzyme activity quantification.

EXPERIMENTAL METHOD

To study the effects of dietary enzyme supplementation, 2 broiler chicken and 3 turkey trials were completed. In general the experiments were designed to examine both the desirable level of enzyme supplementation and also the impact on several cereal grains.

Experiment 1. A total of 96 day-old broiler chicks were housed in battery brooders to study the effect of supplementing hulless barley broiler starter diets (mash) with 0, 125, 250 or 25,000 ppm of the bacterial enzyme source Zymo-Best. The duration of the trial was 3 weeks and growth and feed intake parameters were recorded.

Experiment 2. To study the effect of Zymo-Best on the performance of broiler chickens to market age, 600 broiler chickens were housed in litter floor pens and fed hulled or hulless barley diets with and without enzyme supplementation (250 ppm). This trial simulated commercial conditions in terms of its duration, and use of medications and pelleted diets.

Experiment 3. Six hundred male Nicholas White poults in wire battery brooders were fed diets based on wheat, barley, Scout hulless barley or oat groats, supplemented with Zymo-Best at levels of 0, 100, 200, 400, 800 or 1600 ppm.

Experiment 4. Diets based on wheat, hulless barley or oat groats, with or without 200 ppm Zymo-Best, were fed to 144 Hybrid 1000 broiler poults to 22 days of age. As antibiotics have been reported to improve performance with barley diets, and were administered to all birds in Experiment 1 from 0 to 3 days, an additional treatment consisted of Neo-Terramycin added to the water for the first 3 days.

Experiment 5. Diets based on wheat, barley or hulless barley, with or without 200 ppm Zymo-Best, were fed to approximately 960 Hybrid 1000 broiler turkeys from day-old to slaughter at 13-14 weeks.

Experiment 6. If enzyme sources with ß-glucanase activity are going to be used by the commercial feed industry, it would be desirable to have a simple rapid method of assessing enzyme activity in enzyme sources and complete diets. A gel diffusion assay (modified from Martin and Bamforth, 1983) was tested with this purpose in mind. In this technique, an agar gel containing ß-glucan is placed in petri dishes and then 5 mm wells are cut in the gel. Extracts from the material to be tested are placed in the gel and allowed to diffuse into the gel for 16 hours. At that time the gel is stained with a Congo Red solution for 1 hour and washed. No staining occurs where the ß-glucan has been hydrolyzed and therefore the diameter of the cleared area around the well can be used to estimate enzyme concentration. This technique was used to study the enzyme source used on the above trials in terms of its stability to pH, temperature and the chick's gastrointestinal tract; conditions which might break down the enzyme during steam pelleting or after consumption.

RESULTS AND DISCUSSION

Experiment 1. Addition of the enzyme source to the hulless barley diet in experiment 1 significantly improved growth rate and feed efficiency in broiler chickens, with the maximum growth rate achieved at the highest level of enzyme inclusion (Table 1). However, the response per unit of enzyme source was highest for the lowest dietary levels (125 ppm) which resulted in growth rate only slightly lower than at the 250 ppm level. Because of the near maximum response at low levels, it would appear that the major economical return would occur at an inclusion level of 125 to 250 ppm. It would also seem likely that additional weight gain caused by the 25,000 ppm level may not be due to the breakdown of ß-glucan, but rather some other growth promoting action. The feed efficiency in the latter group was lower and may reflect the addition of larger amounts of the low energy enzyme source.

Experiment 2. The effects of enzyme supplementation on growth rate and feed efficiency are shown in Table 2. At four and six weeks of age dietary enzyme supplementation significantly improved growth rate of broilers fed either hulled or hulless barley diets. Feed to gain ratios were also improved for both the 0 to 4 and 0 to 6 week time periods, although only the latter was statistically significant. The results of this trial strongly support the practical use of enzymes in broiler diets containing barley throughout their production cycle.

Experiment 3. Enzyme supplementation of turkey diets resulted in no significant effect on growth rate and no clear trend in feed efficiency to 6 weeks of age (Table 3). Diets based on both hulless barley and oat groats, but not hulled barley, supported growth equal to wheat, but neither of those cereals equalled the wheat-based diets in feed efficiency. It was interesting to note that mortality decreased significantly as enzyme supplementation increased; mortality of poults fed 0, 100, 200, 400, 800 and 1600 ppm of enzyme averaged 9.7, 9.8, 5.1, 5.1, 3.0 and 2.1% respectively. The implications of this apparent effect are not clear, however, a similar response was noted in a previous chicken broiler trial.

Enzyme assays were conducted on the diets in an attempt to account for the lack of response to Zymo-Best in barley and oat diets. Higher than expected enzyme levels in barley and oat diets without Zymo-Best may be attributable to endogenous ß-glucanse activity, but could also be consistent with cross-contamination in mixing the feed. Added precautions against this possibility were taken in subsequent trials.

Experiment 4. Only the antibiotic treatment significantly increased the growth rate of poults to 22 days (Table 4). Although not statistically significant, an apparent increase in liveweight was associated with Zymo-Best in hulless barley and oat groats diets. Thus, it appears likely that the administration of antibiotics in Experiment 1 prevented the expression of the enzyme effect in that trial.

Experiment 5. The addition of Zymo-Best to barley and hulless barley but not wheat-based diets significantly improved liveweight gains and feed efficiencies to 4 weeks of age (Table 5). Added enzyme had no apparent effect after 4 weeks of age, when the barley and hulless barley diets supported performance nearly equal to that of the wheat-based diets. Final weights and overall feed efficiencies reflected the significant differences that appeared during the starting period. There was no reduction in mortality with added Zymo-Best in this experiment.

Further study is proposed to determine whether the apparent ineffectiveness of enzyme supplementation past 4 weeks of age represents a true age effect on the ability of turkeys to utilize cereals with high ß-glucan levels, or an adaptation to diets containing those cereals.

Experiment 6. The gel diffusion assay was found to be a rapid, simple and reliable method of establishing ß-glucanase activity. An example of the relationship between gel clearing and enzyme activity is shown in figure 1. The assay demonstrated that at least some Zymo-Best activity is retained in the gastrointestinal tract (Table 6) which support the improved performance seen in chicken growth trials. This enzyme source was relatively stable to pH (Table 7) with little loss in activity after 10 min exposure to pH 2. Exposure of Zymo-Best to 60°C did not alter enzyme activity, but at higher temperatures marked loss in activity was noted (Figure 2). This is of concern since most poultry diets are steam pelleted, a process during which temperatures greater than 60°C can be reached. Analyses of the enzyme activity of diets used in experiment 2 revealed a 20 to 36% loss in enzyme activity as a result of pelleting. The beneficial effect of the enzyme supplement in that trial was obvious but variability in the temperature of pelleting and the time diets are exposed to high temperature makes monitoring of enzyme activity in pelleted diets essential. The gel diffusion assay would appear appropriate for this monitoring.

IMPACT

The major benefits are the potential reduction in feed costs as a result of the use of cheaper feed grains and improvement in poultry productivity. These factors would act to improve the competitive advantage of Saskatchewan poultry producers. In the past, Saskatchewan producers have had to pay higher feed costs than their eastern Canada

counterparts. This, despite the fact that Saskatchewan is a major site of grain production. Difficulty in obtaining feed wheat and generally high prices have influenced this problem and the use of increased amounts of barley should have a marked effect on poultry production costs. Information on the utilization of cereal grains such as hulless and hulled barley in poultry diets may improve their export market potential because sales for poultry feed represent an important component of the feed grain market.

Table 1. Three week body weight and feed conversion for broiler chickens fed hulless barley with various levels of the enzyme supplement, Zymo-Best (experiment 1).

Dietary enzyme level (ppm)	Body weight (g)	Feed efficiency (gain/feed)
0	347	.625
125	490	.699
250	496	.719
25,000	540	.667

Table 2. Effect of enzyme supplementation on 4 and 6 week body weight and feed efficiency of broiler chicks fed hulled or hulless barley diets (experiment 2)

Treatment	Body weight(g)		Feed efficiency (gain/feed)	Body weight(g)		Feed efficiency (gain/feed)
	Hulled Barley			Hulless Barley		
	4 week					
Control	842		.571	767		.575
Zymo-Best	883**		.588	915		.599
	6 week					
	Male	Female	Combined sexes	Male	Female	Combined sexes
Control	1771	1449	.485	1654	1409	.483
Zymo-Best	1891**	1581**	.510**	1896**	1577**	.503

1 Data combined for males and females

2 Significantly different ($P < .01$) from corresponding control group (t-test).

Table 3. Effect of enzyme supplementation on liveweight and feed efficiency of male poults to six weeks of age (experiment 3)

Cereal in diet	Level of enzyme in diet, ppm						
	0	100	200	400	800	1600	Mean
				Liveweight (kg)			
Wheat	2.50	2.51	2.47	2.57	2.47	2.41	2.49[a]
Barley	2.40	2.41	2.34	2.30	2.44	2.31	2.37[b]
Hulless barley	2.44	2.58	2.46	2.48	2.42	2.44	2.47[a]
Oat groats	2.45	2.53	2.35	2.51	2.41	2.42	2.44[a]
Mean	2.45	2.51	2.40	2.46	2.44	2.38	2.44
				Feed efficiency (gain/feed)			
Wheat	.710	.696	.652	.703	.689	.667	.686[a]
Barley	.602	.641	.633	.663	.665	.650	.642[b]
Hulless barley	.649	.643	.639	.663	.642	.654	.648[b]
Oat groats	.630	.634	.617	.671	.666	.639	.643[b]
Mean	.648[ab]	.654[ab]	.635[a]	.675[c]	.666[b]	.653[ab]	.655

Table 4. Effect of enzyme supplementation and antibiotic treatment on performance of poults to 22 days of age (experiment 4)

Cereal in diet	Treatment			
	None	Zymo-Best	Antibiotic	Mean
		Liveweight (g)		
Wheat	648	651	682	660
Hulless barley	609	631	678	640
Oat groats	635	665	671	657
Mean	631[b]	649[b]	677[a]	652
		Feed efficiency (gain/feed)		
Wheat	.799	.780	.801	.794
Hulless barley	.717	.758	.740	.739
Oat groats	.734	.737	.747	.739
Mean	.750	.758	.763	.757

Table 5. Effect of enzyme supplementation on performance of turkey broilers (experiment 5)

Cereal in diet	Zymo-Best:	0-4 weeks 0	0-4 weeks 200 ppm	4-10 weeks 0	4-10 weeks 200 ppm	0-13 weeks 0	0-13 weeks 200 ppm
		Weight gain (kg)				Final weight(kg)	
Wheat		.943	.962	3.54	3.57	6.52	6.41
Barley		.814	.888	3.45	3.46	5.95	6.17
Hulless barley		.817	.930	3.49	3.47	6.06	6.18
Mean		.858	.927	3.49	3.50	6.11	6.25
		Feed efficiency (gain/feed)					
Wheat		.716	.704	.548	.554	.486	.490
Barley		.656	.706	.549	.552	.479	.488
Hulless barley		.659	.708	.540	.547	.469	.481
Mean		.677	.706	.546	.551	.478	.486

Table 6. Endo-ß-glucanase activity of gut contents from 4-week broiler chicks fed hulless barley diets with or without enzyme supplementation

	Enzyme Units (per gram material)				
	Feed[1]	Crop[2]	Jejunum[2]	Ileum[2]	Feces[2]
Control	.002 ± .013	ND4	ND	ND	ND
Zymo-Best	.075 ± .005	.011 ± .001	.007 ± .003	.004 ± 0	.004 ± .003

1 Air dry basis.

2 Wet basis.

3 $\bar{X} \pm \overline{SE}$; each mean represents 3 extractions and analyses of the same sample. Gastrointestinal samples were obtained by pooling material from 5 chicks.

4 None detected.

Table 7. Effects of acid conditions on bacterial endo-ß-glucanase activity (Zymo-Best)

pH	Enzyme units (per gram material)	Activity (%)
7.0	85 ± 5[1]	100
5.0	88 ± 8	104
4.0	69 ± 13	81
3.0	75 ± 12	88
2.0	83 ± 13	98
1.0	36 ± 11	42

[1] X ± SE; each mean presents 3 extractions and analyses of the same sample.

Table 8. Effect of pelleting on bacterial endo-ß-glucanase activity in hulled or hulless barley broiler diets supplemented with Zymo-Best

	Enzyme units (per gram material)			
	Hulled barley		Hulless barley	
	Control	Zymo-Best	Control	Zymo-Best
Starter Diets				
Mash	.004±0[1]	.035±.007	ND[2]	.038±.006
Pelleted and crumbled	.004±0	.028±0	ND	.028±.005
Activity lost	0%	-20%		-26%
Finisher Diets				
Mash	.005±.002	.044±.004	ND	.053±.005
Pelleted	.004±0	.028±0	ND	.038±.006
Activity lost	-20%	-36%		-28%

[1] X ± SE; each mean represents 3 extractions and analyses of the same sample.

[2] None detected.

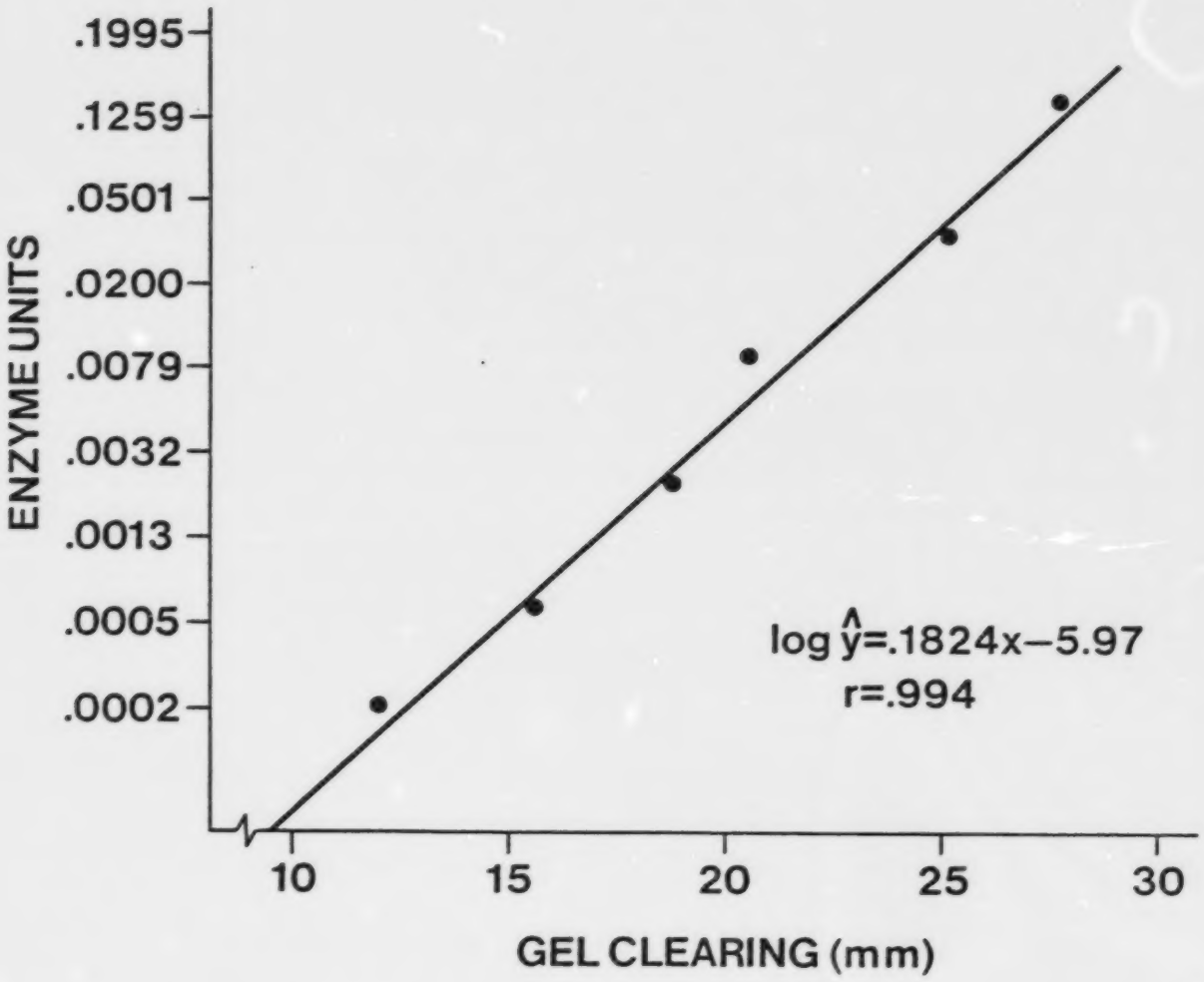

Fig. 1 The relationship between gel clearing and activity of purified endo 1, 3 (4) β-D-glucanase.

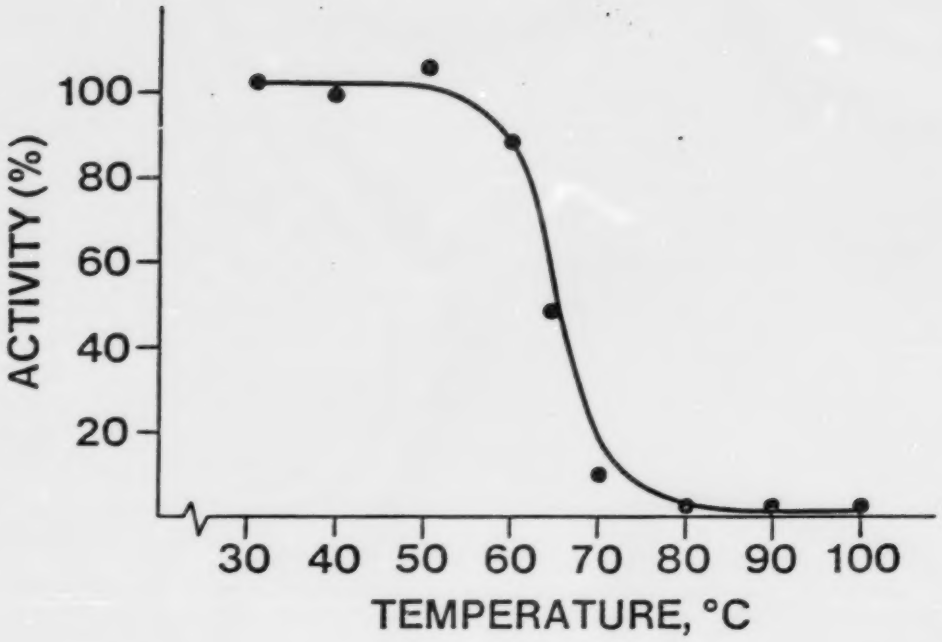

Fig. 2 Bacterial (Zymo-Best) endo- β -glucanase as affected by 10 min exposures to elevated temperatures. Activities are calculated as percent activity at room temperature.

DIETARY ENZYME SUPPLEMENTATION AS A METHOD OF IMPROVING THE NUTRITIONAL VALUE OF CEREAL GRAINS

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Carbohydrate gums in several cereal grains, such as barley, have a detrimental effect on the productivity of poultry. The dietary addition of enzymes capable of breaking down these gums is known to improve the nutritional value of the grain, but many enzyme sources are very costly and therefore cost prohibitive. Recently research trials have provided evidence that a crude enzyme source (Zymo-Best) may be cost effective in breaking down the gums (ß-glucan) found in barley and oats. The objectives of the present study were: 1) to investigate the practical use of this enzyme source in improving the nutritional value of cereal grains for poultry; and 2) to study the factors affecting stability of the enzyme and establish a technique to quantify enzyme activity.

Two trials were conducted to investigate the use of the enzyme source in diets for broiler chickens. In both trials enzyme supplementation markedly improved the growth and feed efficiency of broilers fed hulled or hulless barley. Maximum performance was obtained when 25,000 ppm of the enzyme source was added, but a range of 125 to 250 ppm was adequate to produce the majority of the improvement in performance. The results also demonstrated that enzyme supplementation was beneficial throughout the broiler production cycle and in diets which were pelleted and contained anticoccidial agents and growth promotants. From this research, it can be concluded that enzyme supplementation of barley diets for broiler chickens is commercially applicable. Results fro 3 trials with turkeys were not consistent. In an initial battery trial, enzyme supplementation of turkey diets containing wheat, hulled barley, hulless barley or oat groats did not improve growth rate or feed efficiency regardless of level of enzyme addition (0, 100, 200, 300, 400, 800 or 1600 ppm). In a second trial, enzyme supplementation numerically improved the performance of turkeys fed hulless barley or oat groats while in a third trial performance was significantly improved from 0 to 4 weeks of age for turkeys fed hulled or hulless barley. Production parameters for the remainder of the cycle in the latter trial (4 to 13 wks) were unaffected by enzyme supplementation but the final data for the entire experimental period still reflected the superior early performance. Additional research in turkeys is required to determine the reason for the age effect on productivity improvement due to enzymes. In addition, more data is required before a definite statement can be made about the commercial use of this enzyme source in barley and oat diets for turkeys.

A gel diffusion assay was found to be a rapid, simple and reliable method of establishing enzyme activity. The assay demonstrated that at least some Zymo-Best activity is retained in the gastrointestinal tract; this supports the improved performance seen in chicken growth trials. This enzyme source was relatively stable to pH with little loss in activity after 10 min exposure to pH 2. Exposure of Zymo-Best to 60°C did not alter enzyme activity, but at higher temperatures marked loss in activity was noted. This is of concern since most poultry diets are steam pelleted, a process during which temperatures greater than 60°C can be reached. Analyses of the enzyme activity of diets used in experiment 2 revealed a 20 to 36% loss in enzyme activity as a result of pelleting. The beneficial effect of the enzyme supplement in that trial was obvious but variability in the temperature of pelleting and the time diets are exposed to high temperture makes monitoring of enzyme activity in pelleted diets essential. The gel diffusion assay would appear appropriate for this monitoring.

The major benefits of this study are the potential reduction in feed costs as a result of the use of cheaper feed grains and the improvements in poultry productivity. These factors would act to improve the competitive advantage of Saskatchewan poultry producers. In the past, Saskatchewan producers have had to pay higher feed costs than their eastern Canada counterparts. This, despite the fact that Saskatchewan is a major site of grain production. Difficulty in obtaining feed wheat and generally high prices have influenced this problem and the use of increased amounts of barley should have a marked effect on poultry production costs. Information on the effective utilization of cereal grains such as hulless and hulled barley in poultry diets may improve their export market potential because sales for poultry feed represent an important component of the feed grain market.